

# Linkages Between the Delta and San Francisco Bay

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John Conomos, writing in *The Urbanized Estuary* (1979) described the San Francisco Bay and Delta as "a complex of interconnected embayments, sloughs, marshes, channels and rivers." Geographically, the Bay proper includes a northern reach, which passes from the Delta through Suisun and San Pablo Bay, and the southern reach (South Bay). The two reaches join in Central Bay near the Golden Gate, the connection with the ocean. The components of the Bay-Delta are "interconnected" by water movement, sediment transport and the movement of the animals and plants that comprise the estuary's biological community. An "ecosystem perspective" is essential to successful rehabilitation in any environmental setting, but is especially important in a system as complex, as interlinked and as subjected to human disturbance as the Bay-Delta.

In the long-term the success of the full community of fish and bird resource species will define the success of Bay-Delta restoration. The occurrence and movement of birds, fishes and other resource species illustrate the importance of linkages within the Bay-Delta and of a full ecosystem perspective (Figure 1). San Pablo Bay, South Bay and Central Bay contain immense expanses of shallow water habitat and wetlands or potential wetlands. On the basis of area, habitat and location, alone, these embayments could be the most important nursery grounds for resource species in the Bay-Delta. The SF Estuary Project's *Status and Trends Report on Aquatic Resources* (Herbold et al, 1992) noted that a large component of the Bay resource species use habitat in several of the embayments. They described the Bay fish community in each of these areas and compared that community to the Delta. They stated that the Central Bay is characterized by an especially rich assortment of resource species which enter from the ocean, South Bay and the more freshwater regions to the north. They found San Pablo Bay fishes are typical of an assemblage that can tolerate a range of salinities, and includes summer invasions from the ocean and South Bay. San Pablo Bay is a nursery for Dungeness Crab, once one of the most valuable fisheries in the Bay. Anadromous fish, including shad, salmon and striped bass, must pass through San Pablo Bay. The shallow water habitat and salt ponds of San Pablo Bay, (as well as South Bay) are crucial to a significant proportion of the migratory wading birds and diving ducks that comprise the Pacific Flyway (although not presently a focus of CALFED restoration, the birds of the Pacific Flyway must eventually be considered in the rehabilitation effort). The species of the Suisun Bay fish assemblage that are unique to that embayment were discussed by Herbold et al (1992), but they also emphasized that a large number of the species in Suisun also range downstream. Finally, Herbold et al (1992) concluded that the western Delta "supports very species and very few individuals compared to downstream". The most effective resource restoration would include studies and activities in all embayments, including those with great potential for restoring significant resources directly or facilitating restoration of resources elsewhere.

The ecology of San Pablo Bay and Central Bay are poorly known. What we do know

emphasizes the importance of linkages to the Delta. Most important, we know that the food web of the northern reach, including the animals in San Pablo Bay, is highly dependent upon carbon inputs from the rivers. Internal carbon production (the basic building block of the food web) is too low to support a substantial food web; the carbon in this estuary must come from the rivers and the land. For animals that permanently reside in the sediments, reproduction is tightly tied to river inflows (Figure 2). When river flows increase, these animals grow and reproduce. That growth and reproduction provides the food for many of the most important species of the ecosystem. The ecology of South Bay is better known than the two northern embayments. We have long recognized that river inflows from the Sacramento/San Joaquin controls the flushing of South Bay and thus its water quality. We also know that the internal carbon production that drives the South Bay food web is finely tuned to the annual inflows of freshwater from the upstream rivers to this system (freshwater from the northern reach penetrates, flushes and stratifies South Bay when flows are in excess of ~40,000 cfs). Changes in water management could have implications for all these processes. Such changes could affect carbon input to San Pablo Bay, they could affect carbon production in South Bay, and thus they could affect both the nursery function and the success of resource species in these rich subsystems. Recognition and study of the ecosystem-wide implications of these changes is essential in their evaluation.

We also know that the quality of habitat in San Pablo Bay and Central Bay can have important impacts on what are considered measures of restoration success in the Delta. In the 1980's a high proportion of the striped bass of the Bay-Delta were infested with lesions, which today we recognize as symptomatic of excessive exposure to pollutants, probably from the Bay habitat of the fish. One possible explanation of the decline in Sturgeon is release of Se into Carquinez Strait and San Pablo Bay. During low flow regimes this Se is spread throughout Suisun and San Pablo Bays contaminating sturgeon and diving ducks through both embayments. Hydraulic mining debris created ~50 Km<sup>2</sup> of mercury contaminated marsh in the late 1800's in San Pablo Bay. If this marsh is restored in the future, it is possible that mercury contamination of large fish and birds could worsen and be transported throughout the ecosystem. Fish which carry lesions or levels of mercury or selenium unsafe for human consumption into the Delta from downstream will not contribute to success in restoration.

Thus processes that will control successful restoration in the Bay-Delta ecosystem have implications both upstream and downstream from their origin in this complicated environment. Environmental processes and populations of animals in one location are often supported by processes in another location. Management of one environmental issue can have important implications for other environmental issues. Such complexities must eventually be recognized, studied and incorporated into plans for a successful restoration. This can best be facilitated by incorporating a whole ecosystem view into the San Francisco Bay restoration effort.